DEWATERING ASSESSMENT
RELOCATION OF FLEET REC PARK
NAVAL STATION NORFOLK
NORFOLK, VIRGINIA

June 24, 2005

Prepared For:
VIRGINIA DEPARTMENT OF TRANSPORTATION
Mr. Mike Sarros
1700 N. Main Street
Suffolk, Virginia 23439
(757) 925-1648

Prepared By:
MARSHALL MILLER AND ASSOCIATES
11277 Airpark Road, Suite 203
Ashland, Virginia 23005
(804) 798-6525

MM&A Project Number: H0194

Reviewed By:

James Martin

James T. Martin, Jr., P.G.
Marshall Miller & Assoc.
Senior Scientist

Prepared By:

Pete Moncla

A.M. "Pete" Moncla, P.G.
Groundwater Management Assoc.
Senior Scientist

TABLE OF CONTENTS

1.0 INTRODUCTION

Marshall Miller & Associates, Incorporated (MM&A) has completed the dewatering assessment to relocate a Navy recreational facility (referred to as Fleet Rec Park) associated with the Virginia Department of Transportation's (VDOT's) Route 337 improvements in Norfolk, Virginia, see **Map 1** in **Appendix I**. The new Fleet Rec Park (FRP) is proposed at another portion of the Naval Station Norfolk (NSN) referred to as the Camp Allen Salvage Yard (CASY), which is a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) unit. On behalf of VDOT, MM&A evaluated the groundwater dewatering (i.e. pumping) anticipated to occur during construction. The design for the south and north portions of the FRP is shown on **Map 2** and **Map 3**, respectively (**Appendix I**). This study included the following: 1) reviewed the Navy's most recent groundwater modeling report, 2) reviewed VDOT construction plans, 3) modified the existing groundwater model, and 4) evaluated the effects of anticipated dewatering utilizing the groundwater model.

1.1 SITE HISTORY

The Navy provided VDOT with guidance on conducting dewatering operations entitled *Technical Memorandum, Dewatering Requirements for the I-564 Intermodal Connector Project in the Camp Allen Area* (CH2MHill, August 2002). The memorandum summarizes the dewatering requirements, including groundwater modeling prior to pumping, to ensure no adverse effect on the Navy's hydraulic containment of a groundwater plume associated with the CASY and adjacent Camp Allen Landfill (CALF). The most recent report is the 2003 CALF Modeling Report by CH2MHILL. Groundwater elevations from September 2003 at the proposed park appeared to range from 6.8 to 9.8 feet above mean sea level (a.m.s.l.). [Note: The vertical datum used by the Navy and the CALF model is the 1988 NAVD. The vertical datum used in the VDOT design is the 1929 NGVD. At the NSN, the NAVD is 0.82 feet higher than the NGVD, and such conversions were made throughout this study.]

1.2 CONSTRUCTION PLANS

The FRP relocation consists of constructing four softball/baseball fields, three soccer/football fields, picnic buildings, bathrooms and parking lots. MM&A reviewed plans sheets and discussed the plans with VDOTs design team. Proposed utilities for the park include storm sewer, sanitary sewer, potable water, irrigation water, electric, and electric duct bank. Other excavations will include footers/foundations for buildings and fences.

MM&A evaluated which utilities may extend deep enough into groundwater to require dewatering for installation. The table in **Appendix II** shows the depths of installation for the various sub-grade features. Most features do not extend beneath a depth of three to four feet below existing grade. In addition, narrow diameter utilities (≤ 6-inches) such as potable water, irrigation water and electrical are specified for installation with a trencher (i.e. ditch witch) and are not anticipated to require dewatering. The deepest features are associated with light poles, which have foundation designs of either helical screw for standard poles or pile driven for sport lights that have eliminated the need for dewatering. In short, MM&A identified two features (storm sewer and sanitary sewer) with sections that will extend into groundwater with construction methods where dewatering is likely. **Map 4 (Appendix I)** depicts that all proposed utility construction (including the storm sewer and sanitary sewer) exists within the 1.0 microgram per liter (μg/L) volatile organic compound (VOC) plume boundary line as provided in the technical memorandum. These two features are described below.

Storm Water Drainage System

Approximately 2,500 feet of storm sewer (reinforced concrete pipe) are proposed ranging in diameter from 23 to 45 inches. The proposed invert elevations range from a high of 8.83 feet (near the east parking lot) to a low of 2.93 feet at the outfall to a tributary of Boush Creek (NGVD 29). The VDOT design team changed the storm water piping to an elliptical shape, where feasible, to reduce the depth of installation. Additionally, the plan sheets designate sealing of pipe joints and placement of low permeability collars in the backfill to avoid an enhanced migration pathway for shallow groundwater.

Sanitary Sewer

Approximately 2,500 feet of sanitary sewer line are proposed with diameters ranging from 6 inches to 8 inches. The sanitary sewer will be a gravity system with a high invert elevation of 10.8 feet (near the softball/baseball fields) to a low invert of 3.5 feet that ties into an existing pump station along Ingersol Street (NGVD 29).

2.0 MODELING METHODOLGY

The modeling efforts focused on determining if VDOT's dewatering would adversely effect the Navy's plume containment. The overall plume containment consists of shallow extraction wells, deep extraction wells (which capture some flow from the shallow aquifer) and other discharge boundaries (*Groundwater Flow Model Report, Camp Allen Landfill, CH2MHill, CTO Task Order 156*). MM&A designed the pumping simulations and performed the modeling in conjunction with Groundwater Management Associates, Incorporated (GMA).

Most of the shallow groundwater in the area is being recovered by seven shallow wells screened in the Columbia (Surficial) Aquifer and by six deeper wells screened in the underlying Yorktown-Eastover Aquifer. The elevation of the existing ground surface ranges from approximately 7 to 13 feet. In September 2003, water levels in the area were higher than in previous years, ranging in elevation from 6.8 feet to 9.8 feet (NAVD 88). The surface water elevation of the tributary to Boush Creek is reported as 4.03 feet on the plan sheets (NGVD 29).

In the 2003 CALF Modeling Report, CH2MHILL modified their original 2001 model to account for two new pumping wells, different pumping rates, and higher observed groundwater levels. The modifications performed by CH2MHILL and reproduced as part of this study included: 1) the addition of two new pumping wells (well B-EW8A row 86, column 111, layer one; well A2-EW3B, row 66, column 55, layer three), 2) new flow rates for the 13 pumping wells (Table 2-1 of the CALF Modeling Report), and 3) higher recharge rates (recharge increased by a factor of 1.75). The 2003 CALF Modeling Report presents maps of simulated hydraulic head for the Columbia and Yorktown-Eastover Aquifers after these modifications were made to the 2001 model. These two maps produced by CH2MHILL are included in this report as **Figures 1** and **3 (Appendix III)**. Maps of hydraulic heads produced by the updated model as part of this study are included as **Figures 2** and **4** (**Appendix III**) and agree with the maps of hydraulic heads shown in **Figures 1** and **3**.

MM&A placed conservative assumptions on the dewatering parameters such that overestimates of drawdown would occur to depict worse case conditions. Those assumptions made regarding the installation of the storm and sanitary sewers included the following.

- Storm pipes will be installed in excavations up to 5 feet wide.
- Excavations will extend to 1 foot below the bottoms of the pipes to allow placement of a gravel bed.
- Approximately 80 feet of storm pipe will be installed in one day.
- Approximately 125 feet of sanitary pipe will be installed in one day.
- The installation will proceed 7 days/week with the sanitary sewer installed immediately after the storm sewer (a total of approximately 51 consecutive days).
- Dewatering the entire open section of trench 12 hours per day.

3.0 MODELING RESULTS

Figure 5 (Appendix III) shows the locations of the proposed storm sewer (blue) and the sanitary sewer (green). The purple line represents an existing 36-inch reinforced concrete pipe. The gray cells in **Figure 5** act as drains in the groundwater flow model. Gray cells containing the blue storm sewer and the green sanitary sewer were added as part of this study and represent both the 1) short-term excavations with associated dewatering and 2) the long-term conditions post installation. The remainder of the gray cells represent drains that are part of the original CH2MHILL groundwater flow model.

The drains were entered into the groundwater flow model as lines, with starting and ending elevations, and with "conductance-per-length" values. Because the drains added to the model represented both the 1) short-term excavations and 2) the potential long-term effects, the elevations of the drains and the conductance-per-length values varied over time. For the construction phase, drain elevations were chosen that were one foot below the bottom elevation of the pipe (i.e., the elevation of the bottom of the excavation where the gravel bed is to be placed). For the period of time after the pipes were installed, drain elevations were chosen that represented the higher of 1) one foot below the bottom elevation of the pipe (i.e., the bottom of the gravel bed), or 2) the elevation of Boush Creek for the two storm sewers that will terminate at this water body.

Two conductance-per-length values were used for the model drains. During the construction phase when the excavations are dewatered, conductance of the model drains is highest. The conductance-per-length values that were used for the drains to represent the construction phase were calculated based on the following formula:

conductance-per-length = hydraulic conductivity of the native sediment * pi

The proposed storm and sanitary sewers pass through areas having a hydraulic conductivity of either 10 or 50 feet/day. Conductance-per-length values of model drains representing excavations in these were 31.4 and 157 feet/day, respectively. As a comparison, the conductance-per-length value for Boush Creek is approximately 10 feet/day. The conductance-per-length value used for the existing 36-inch pipe in the original groundwater flow model prepared by CH2MHILL was approximately 0.00004 feet/day. The conductance-per-length value used for the storm sewer in this study was 0.01 feet/day, 250 times greater than the value used for the existing 36-inch pipe for a conservative approach. A value of 0.001 feet/day was used for the sanitary sewer, which is a smaller pipe and requires less excavation (but still 25 times greater than that used for the 36-inch pipe in the original CH2MHILL model).

Figures 6 through **19** (**Appendix III**) show the influence of the storm sewer and the sanitary sewer on water levels within the Columbia Aquifer both during the construction phase and following construction. In computing drawdowns, starting heads were taken from **Figure 2**. A localized cone-of-depression resulting from the dewatering is shown to migrate along the storm and sanitary sewers as construction progresses over the period (51 days). The figures also show a slight lag time between the termination of pumping for a given section of trench and the re-equilibration of water levels to pre-pumping elevations. Therefore, **Figure 18** was prepared to show conditions 90-days after pumping began. **Figure 18** shows that either 1) the movement of water particles is not discernible in most cases (i.e. no discernible influence) or 2), where discernible, particles follow pathlines consistent with the groundwater flow patterns simulated by the CALF 2003 flow model (**Figure 1**).

Map 4 (**Appendix I**) shows that the closest capture zone to a dewatering location is the portion of storm sewer between the CASY and CALF-Area B (near the proposed east parking lot at Structure 4-9). This segment of storm sewer partially lies within the capture zone formed by mainly extraction well B-EW3A. All other remaining sections of storm sewer and sanitary sewer lie outside the capture zones. Even with overestimated dewatering parameters, **Figure 18** shows no movement away from the capture zones, and in particular, no movement is seen away from the capture zone near storm water Structure 4-9.

To evaluate any potential long term effects, **Figure 19** depicts site conditions approximately three years after construction began. The maximum estimated drawdown at Day 1,000 is <0.05 feet, indicating that the long-term impact of the new storm and sanitary sewers on groundwater flow is non-detectable. Additionally, these long term results should further overestimate the impact of the drains on water levels because the simulations did not reflect the proposed low permeable collars.

4.0 MODELING CONCLUSIONS

All proposed FRP construction activities are within the plume. It appears that only two features (storm sewer and sanitary sewer) will extend into groundwater during construction such that dewatering is likely. The 2003 CALF groundwater flow model was modified to include drain cells representing these storm sewers and sanitary sewers. Conservative assumptions were placed on the dewatering parameters such that overestimates of potential drawdown would occur to depict worse case conditions. Computer modeling indicates that the drains will have very little short-term effects and no discernable long-term effect on groundwater flow patterns. In summary, this modeling analysis shows that it is highly unlikely the storm sewers or sanitary sewers would impact the effectiveness of the groundwater containment/recovery efforts. It is also our opinion that if limited dewatering is necessary to install any of the other sub-grade features (which would have an even smaller excavation disturbance), then a similar unlikelihood of adverse effects on the recovery efforts is expected.

5.0 MONITORING EVALUATION

The technical memorandum specified groundwater monitoring to verify the dewatering model results. Because all dewatering will occur inside the plume, no testing for volatile organic compounds (VOCs) is applicable. Instead the memorandum specified groundwater level measurements for collection twice daily from two wells within a 100-foot radius of a dewatering location. MM&A agrees with performing water level monitoring during construction; however, we believe that an adequate level of protection to the capture zones can be accomplished using the existing network of monitoring wells, particularly those wells closest to the capture zones. Accordingly, we propose using the following existing shallow monitoring wells for measuring drawdown: A-2MW29, B-MW18A, B-MW19A, and B-MW9A. These monitoring wells are deemed suitable locations to monitor potential influences on both the eastern and western network of shallow extraction wells. The modeling performed in this study indicates induced drawdown levels at these wells of less than 0.5 feet. Additional drawdown would also most likely not adversely effect the Navy's capture zones based on the following: distance of the Navy's extraction wells from most construction features, the limited days of pumping and the conservative modeling parameters in this study. Should actual drawdown measurements at these proposed monitoring wells increase by an amount deemed substantial, such as an additional 0.5 feet (equivalent to a total of one foot of drawdown), then additional groundwater modeling may be considered.

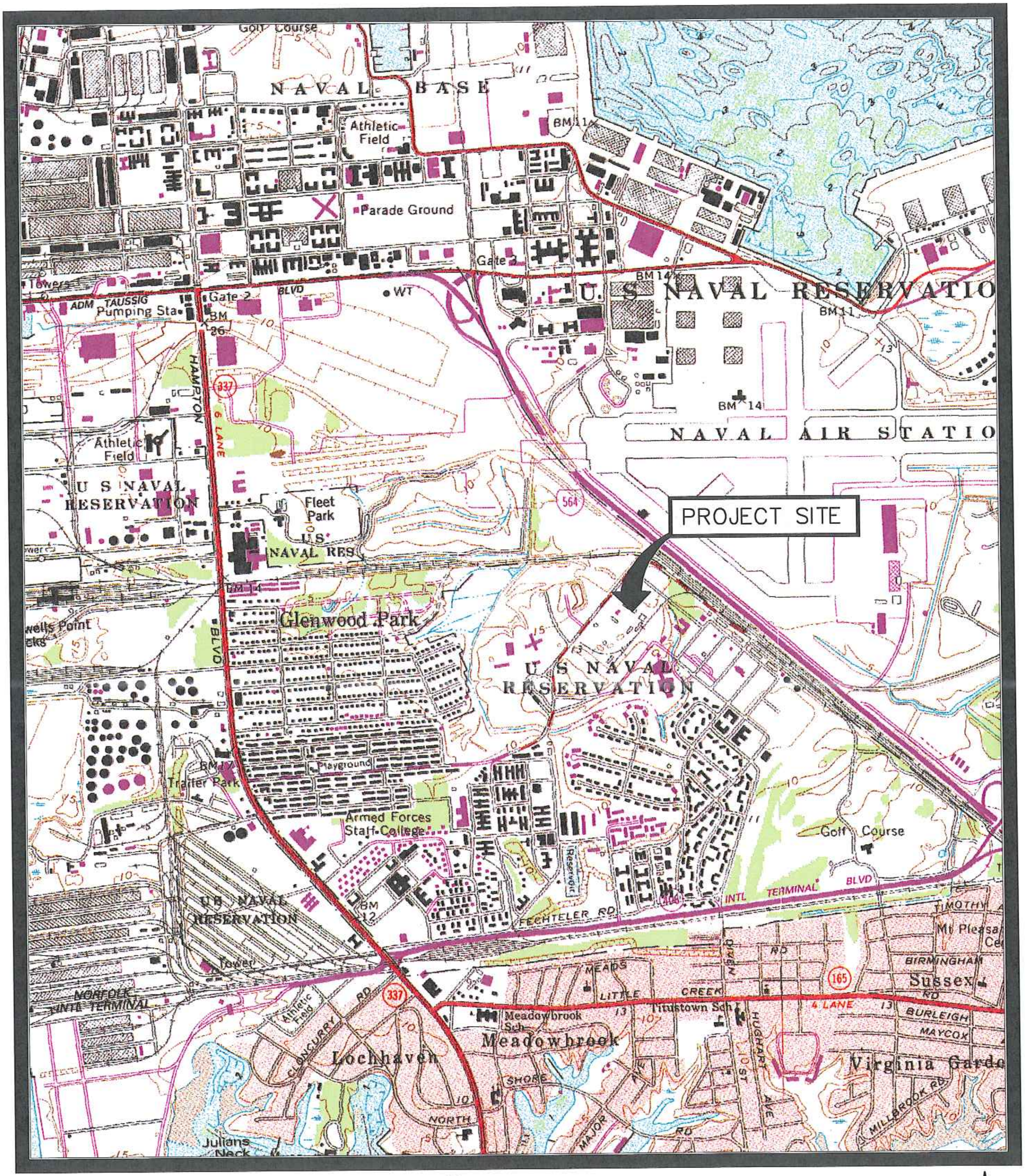
Allowances should also be made for variations in groundwater levels such as natural fluctuations of the water table from precipitation and potential tidal influences. Therefore, groundwater should be measured in 1) the same monitoring wells chosen as dewatering observation points prior to pumping to establish background trends in water levels, 2) more distant shallow wells to observe natural fluctuations from rainfall during pumping (such as A-GW3 and B-1W) and 3) a shallow well near Boush Creek to observe potential tidal influences during pumping (such as A-MW17A located 1,450 feet to the east).

6.0 RECOMMENDATIONS

Based on this dewatering assessment, MM&A suggests that VDOT consider the following recommendations:

1. Follow the guidance provided in the *Technical Memorandum, Dewatering Requirements for the I-564 Intermodal Connector Project in the Camp Allen Area* (CH2MHill, August 2002). This includes requiring the contractor (once selected) to submit a Health and Safety Plan and Material Handling Plan.
2. Discuss the plan for groundwater monitoring with the Navy to instead use the existing monitoring well network and focus more on monitoring wells closer to the Navy's extraction wells.
3. Finalize the preparation with the Navy to use the existing Camp Allen Treatment Plant to receive and treat contaminated groundwater extracted during dewatering.

Appendix I
Maps

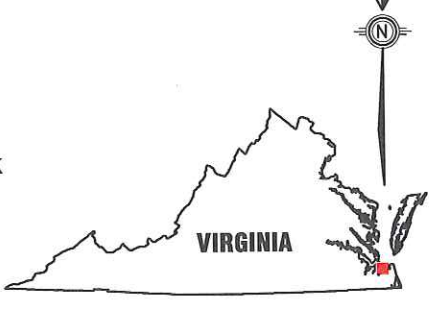


MAP 1 - VICINITY MAP

FLEET REC PARK - NAVAL STATION NORFOLK
NORFOLK, VIRGINIA

2,000' 0 2,000'

SCALE 1:24,000



Prepared by:

MARSHALL MILLER & ASSOCIATES

H0218 **2/15/05**

USGS 7.5' NORFOLK NORTH, VA QUADRANGLE - 1965
PHOTOREVISED 1986, PHOTOINSPECTED 1989
CONTOUR INTERVAL=5'

Appendix II

Table

FEATURE	DEPTHS	IS DEWATERING EXPECTED?
UTILITIES		
STORM SEWER	INVERT ELEVATIONS RANGE FROM 9.85 TO 2.93 FEET.	YES
SANITARY SEWER	INVERT ELEVATIONS RANGE FROM 10.8 TO 3.45 FEET.	YES
POTABLE WATER	MAXIMUM TOTAL DEPTH APPROX. 3.5 FEET	NO
IRRIGATION WATER	MAXIMUM TOTAL DEPTH APPROX. 2.5 FEET	NO
ELECTRIC DUCT BANKS	MAXIMUM TOTAL DEPTH APPROX. 3.5 FEET	NO
ELECTRIC (UNDERGROUND LINES AND LIGHT POLES)	MAXIMUM TOTAL DEPTH APPROX. 2.0 FEET	NO
STRUCTURES		
BUILDINGS (SHELTERS, RESTROOMS, OFFICE, STORAGE)	MAXIMUM CONCRETE FOOTER DEPTH IS 4 FEET	NO
PLAYGROUND EQUIPMENT FOUNDATIONS	VOLLEYBALL NET 4 FOOT FOUNDATION AND 0.66 FEET FOR SAND. HORSESHOE FOUNDATION 0.833 FEET.	NO
DUGOUTS	3 FOOT DEEP CONCRETE FOOTING	NO
FACILITY FENCE POSTS (6-FT. TALL OUTER FACILITY FENCE)	3 FOOT DEEP CONCRETE FOOTING OR DRIVE POINT INSTALLATION	NO
BALL FIELD FENCING	MAXIMUM CONCRETE FOOTER DEPTH IS 3.5 FEET	NO
MISCELLANEOUS		
LANDSCAPING	TREES AND SHRUBS ARE PLANNED ALONG PROPOSED BUILDINGS, FENCES AND PARKING. THE MINIMUM ROOT BALL DEPTH FOR TREES IS AS DEEP AS 1.75 FEET	NO
LIGHTS POLES INCLUDING SPORTS LIGHTS	NO EXCAVATIONS ARE PROPOSED. INSTEAD THE DESIGN USES HELICAL FOUNDATIONS FOR REGULAR LIGHTS POLES AND DRIVE PILES FOR SPORTS LIGHT POLES.	NO
COMMUNICA-TIONS	NO EXCAVATIONS ARE PROPOSED. INSTEAD THE DESIGN USES HELICAL FOUNDATIONS	NO
NAT.GAS	NONE PROPOSED IN PLANS	NO
STEAM LINE	NONE PROPOSED FOR THIS PROJECT	NO

Appendix III
Modeling Figures

Figure 1. CH2MHILL Figure 2-6

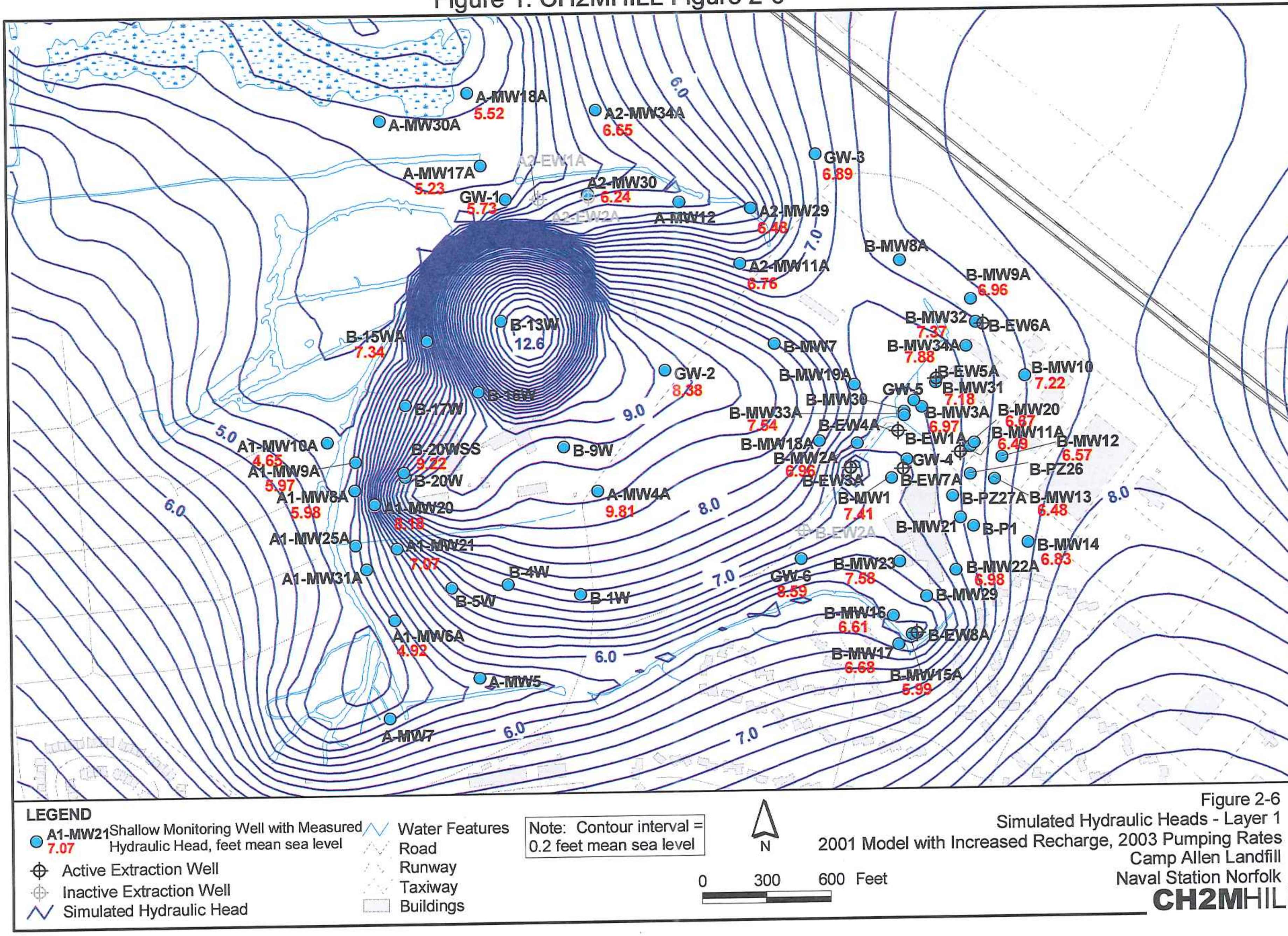
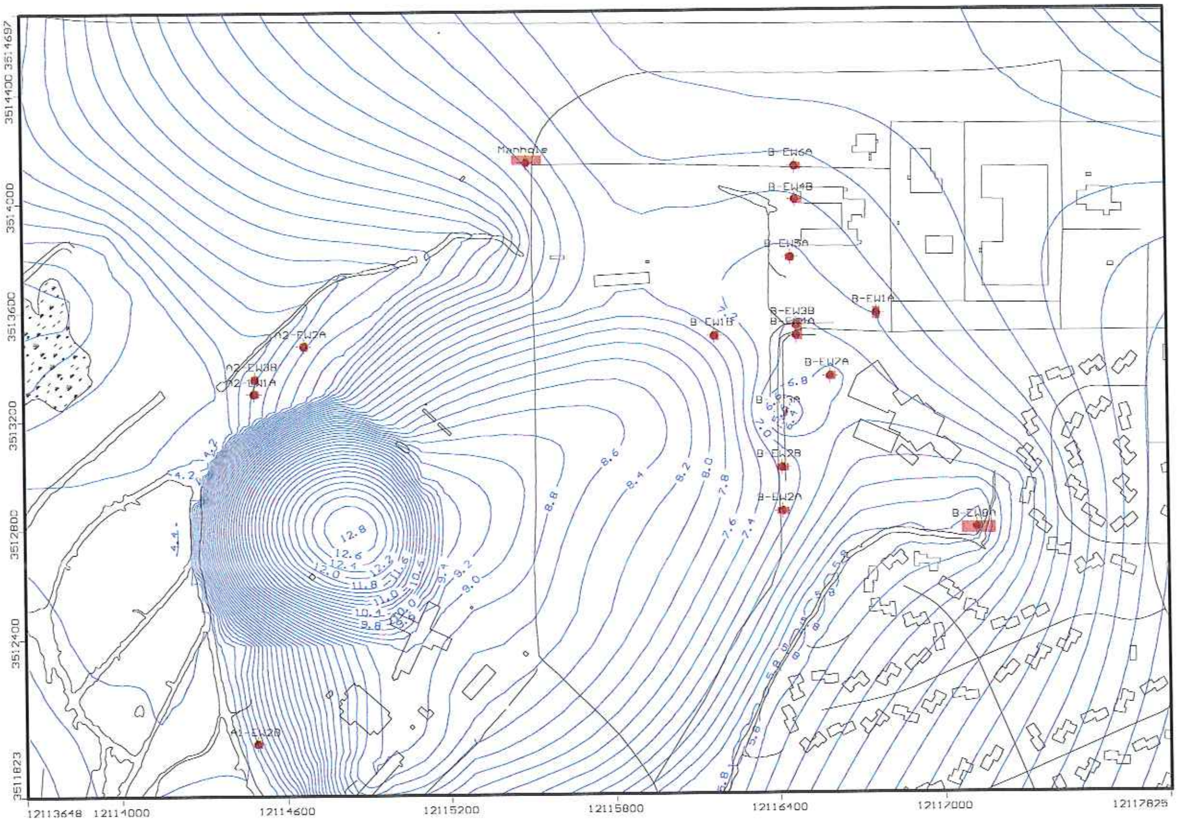
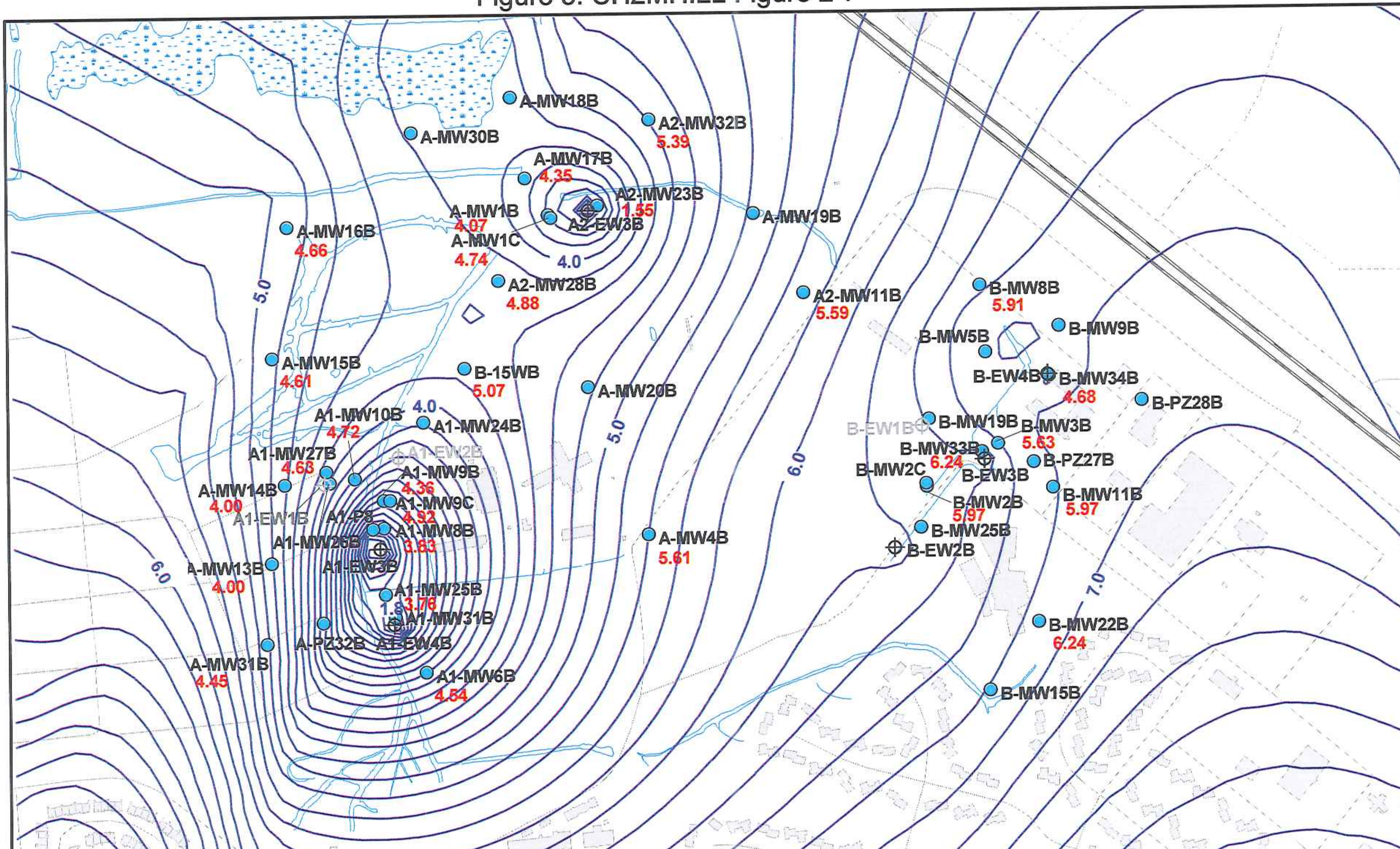


Figure 2. Simulated Hydraulic Heads, Layer 1 (Columbia Aquifer), Increased Recharge (2003)



Groundwater Management Associates, In Project: Navy Recreational Facilit Description: Increased Recharge 2003 Modeller: Pete Moncla 26 Jan 05	Visual MODFLOW v.3.1.0, (C) 1995-2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 3. CH2MHILL Figure 2-7



LEGEND

A-MW31B 4.45 Deep Monitoring Well with Measured Hydraulic Head, feet mean sea level

Active Extraction Well

Inactive Extraction Well

Simulated Hydraulic Head

Water Features

Road

Runway

Taxiway

Buildings

Note: Contour interval = 0.2 feet mean sea level

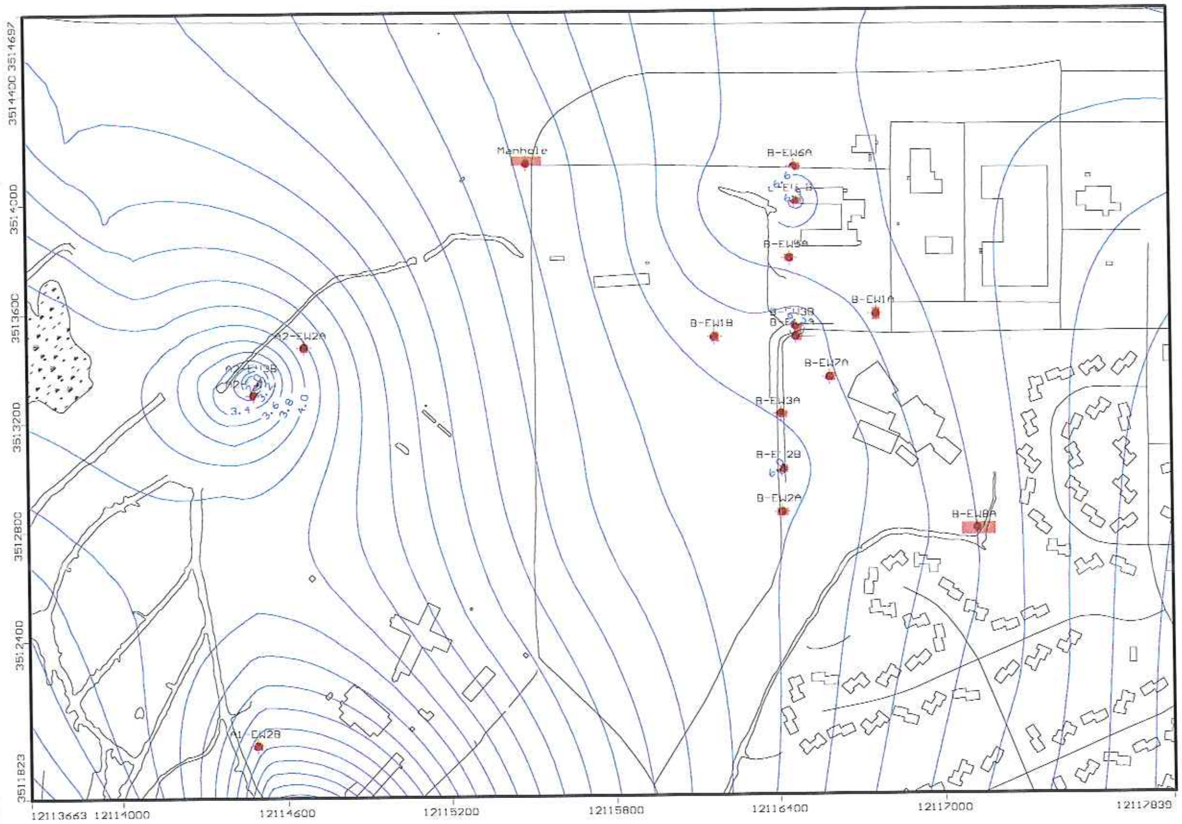
N

0 300 600 Feet

Figure 2-7
Simulated Hydraulic Heads - Layer 2
2001 Model with Increased Recharge, 2003 Pumping Rates
Camp Allen Landfill
Naval Station Norfolk

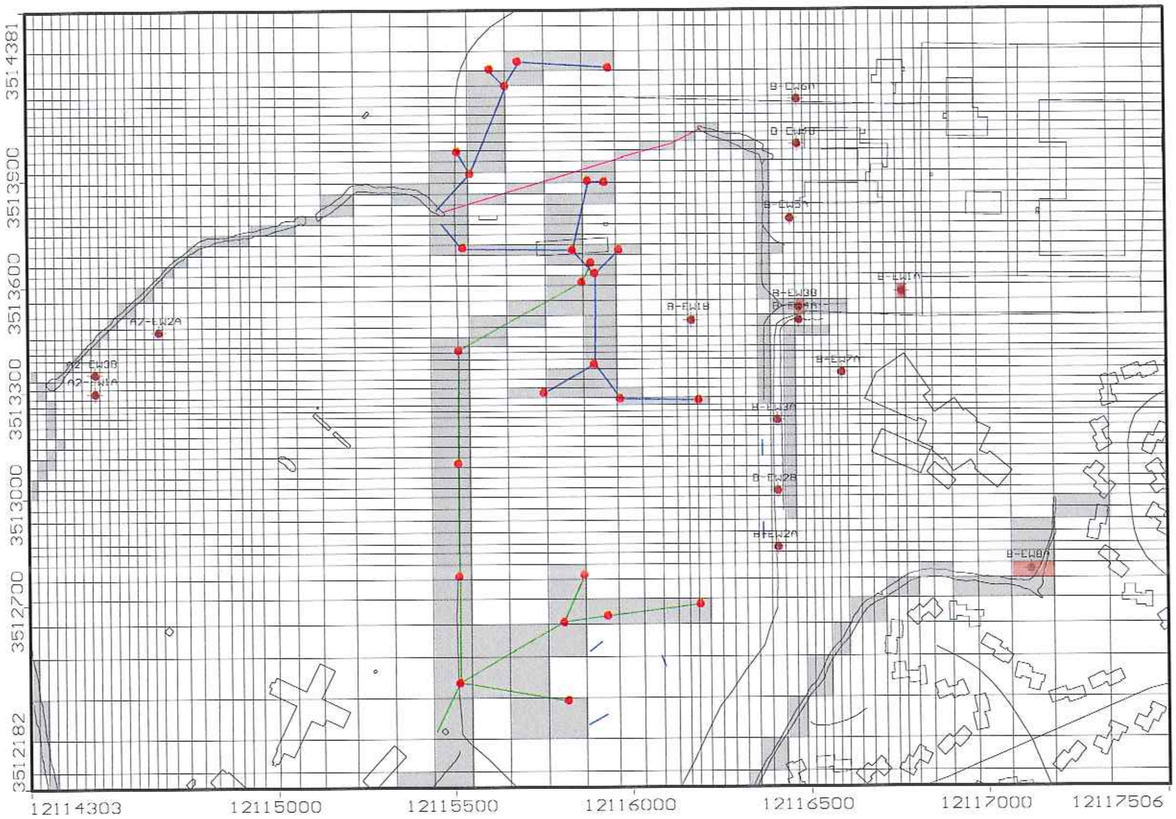
CH2MHILL

Figure 4. Simulated Hydraulic Heads, Layer 3 (Yorktown-Eastover Aquifer), Increased Recharge (2003)



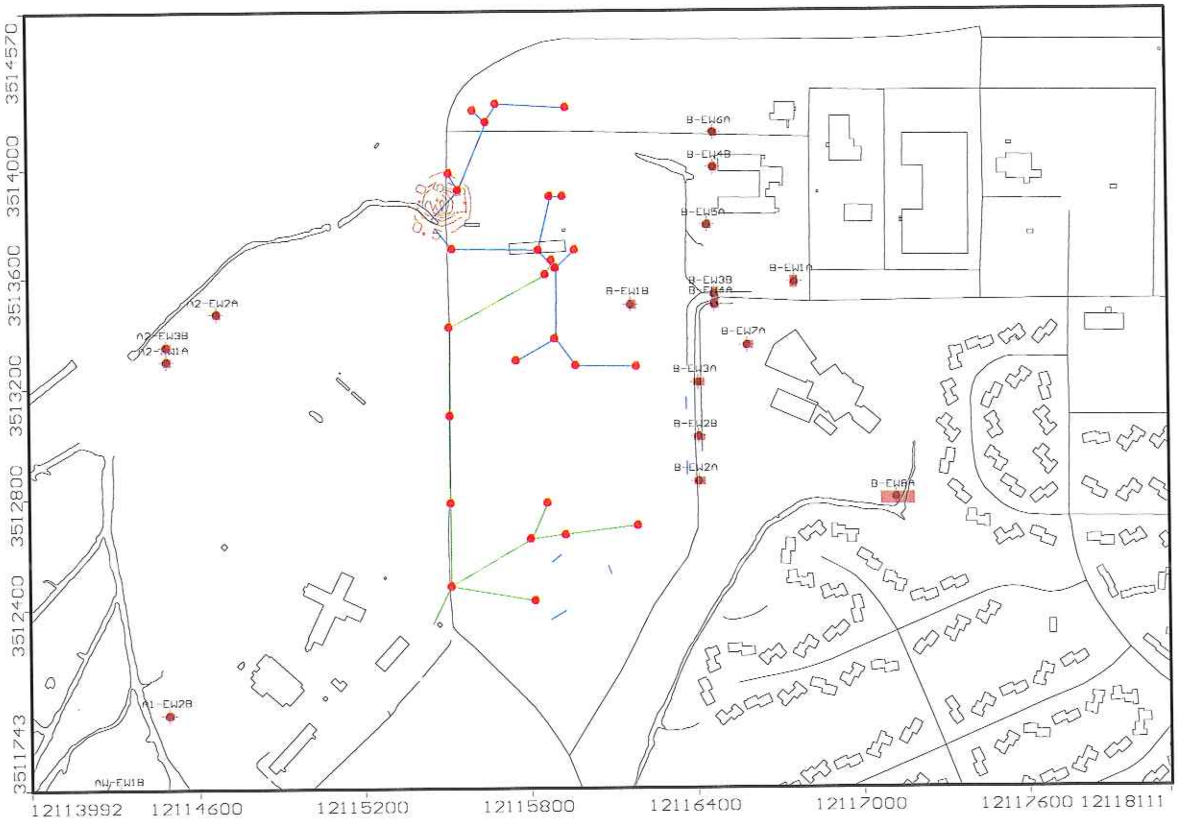
Groundwater Management Associates, In Project: Navy Recreational Facilit Description: Increased Recharge 2003 Modeller: Pete Moncla 26 Jan 05	Visual MODFLOW v.3.1.0, (C) 1995-2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 3

Figure 5. Locations of Drains
(gray represents cells containing drains; blue represents storm drain, green represents sanitary sewer, and purple represents existing storm drain)



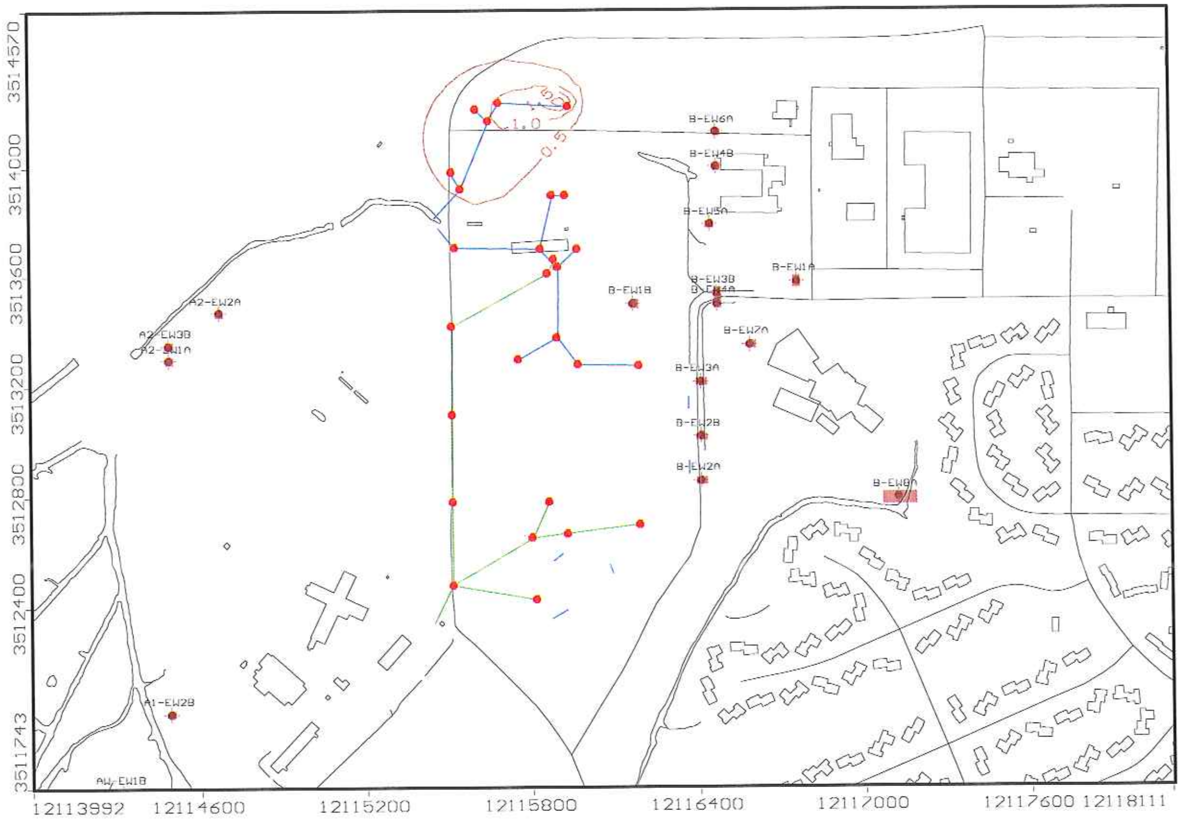
Groundwater Management Associates, In	Visual MODFLOW v.3.1.0, (C) 1995-2002
Project: Norfolk Naval Base	Waterloo Hydrogeologic, Inc.
Description: Drains	NC: 158 NR: 157 NL: 3
Modeller: Pete Moncla	Current Layer: 1
4 Apr 05	

Figure 6. Drawdown after 0.5 Days
(contour interval = 0.5 foot)



Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 0.5 days Modeller: Figure 6 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

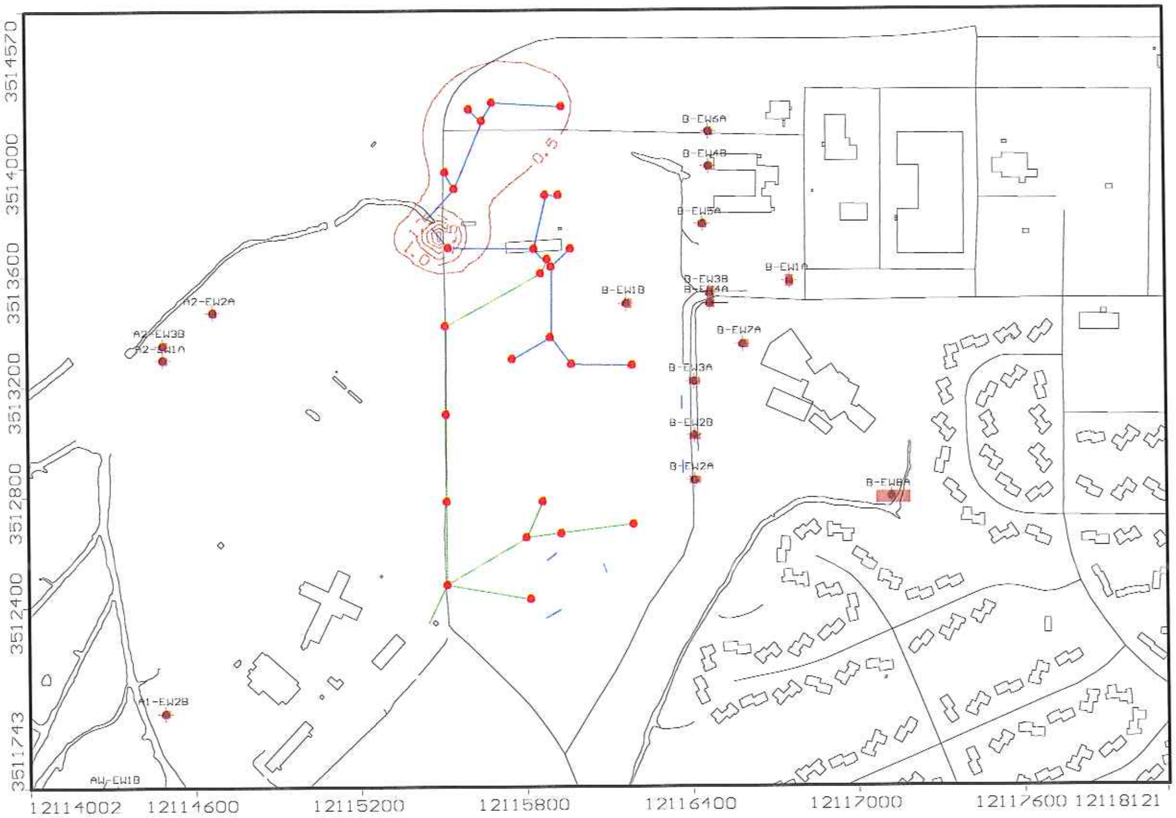
Figure 7. Drawdown after 9.5 Days (contour interval = 0.5 foot)



Groundwater Management Associates, In
Project: Norfolk Naval Base
Description: drawdown, 9.5 days
Modeller: Figure 7
27 May 05

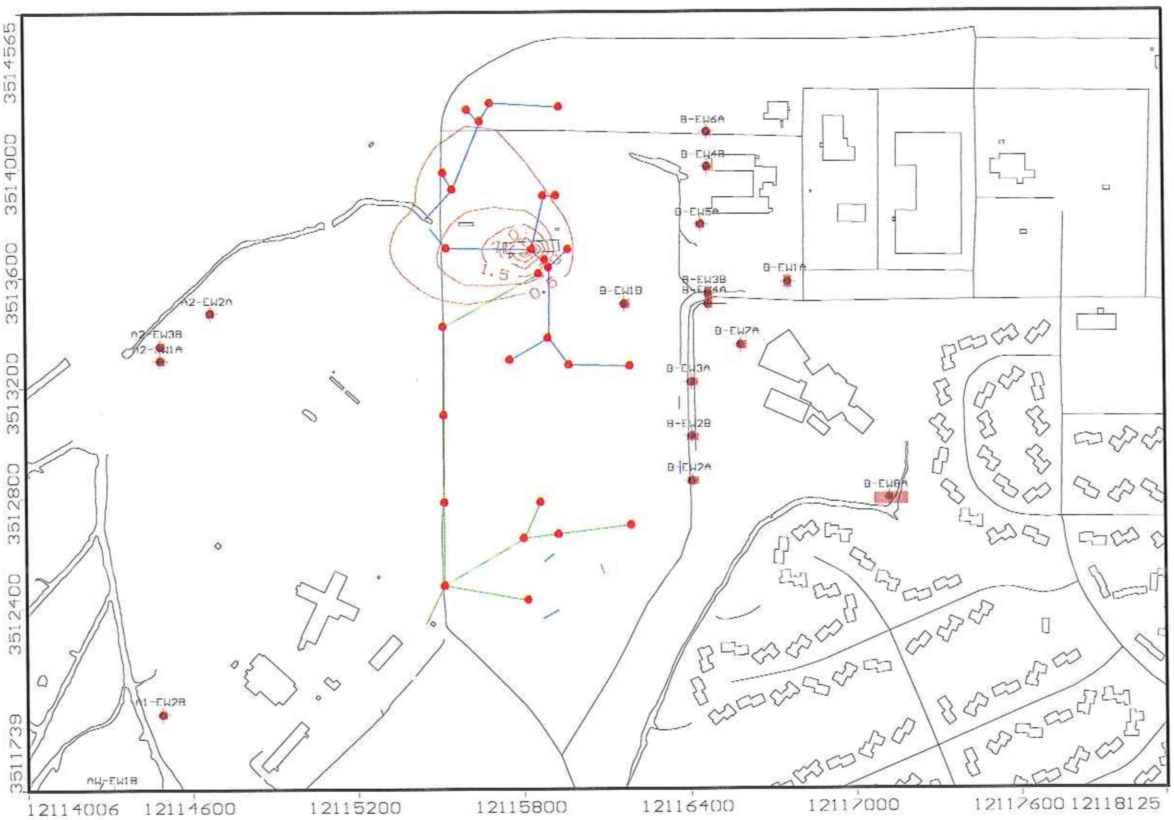
Visual MODFLOW v.3.1.0, (C) 1995–2002
Waterloo Hydrogeologic, Inc.
NC: 158 NR: 157 NL: 3
Current Layer: 1

Figure 8. Drawdown after 10.5 Days (contour interval = 0.5 foot)



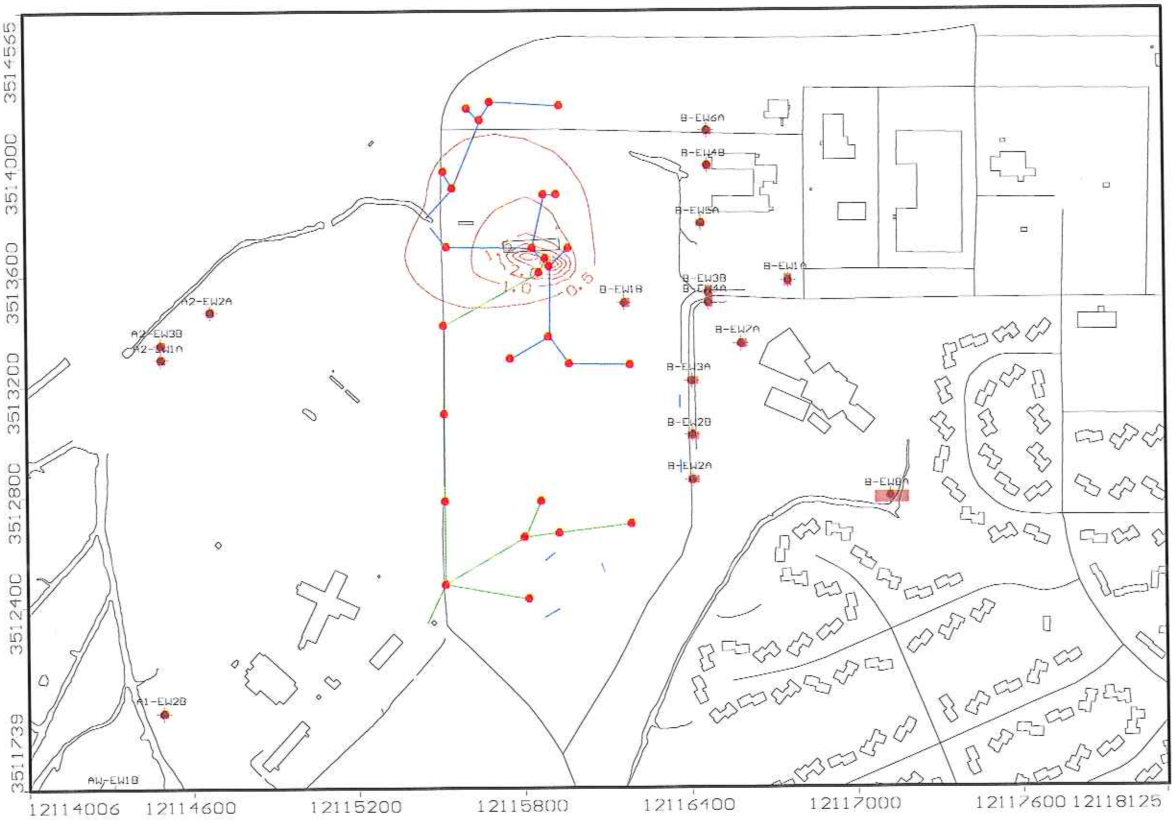
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 10.5 days Modeller: Figure 8 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 9. Drawdown after 15.5 Days (contour interval = 0.5 foot)



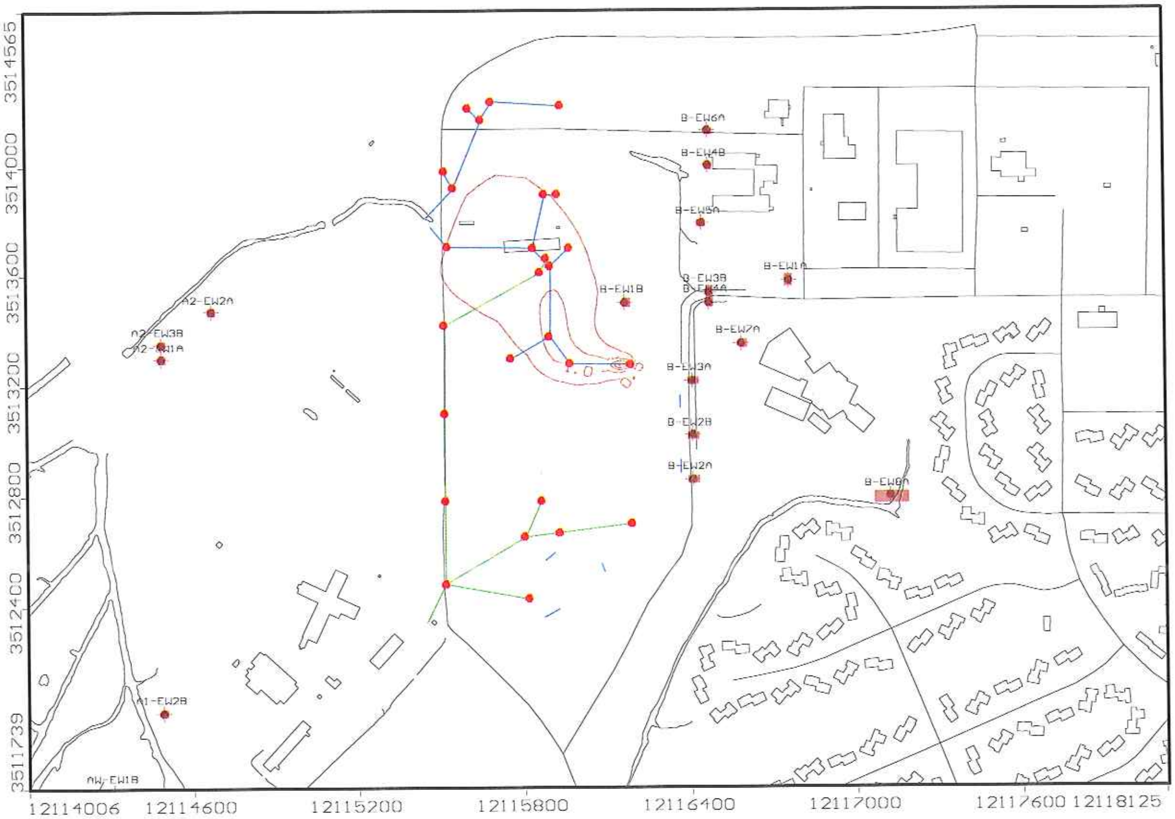
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 15.5 days Modeller: Figure 9 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 10. Drawdown after 19.5 Days
(contour interval = 0.5 foot)



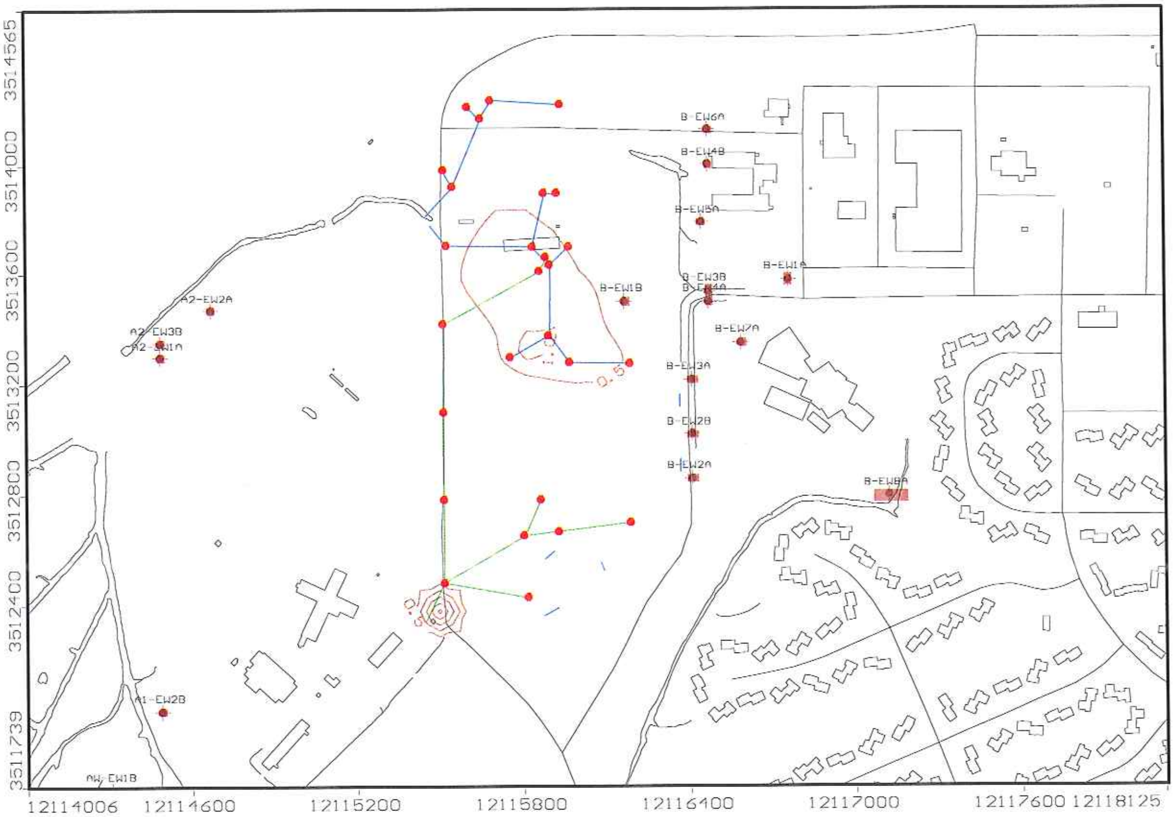
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 19.5 days Modeller: Figure 10 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995-2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 11. Drawdown after 28.5 Days (contour interval = 0.5 foot)



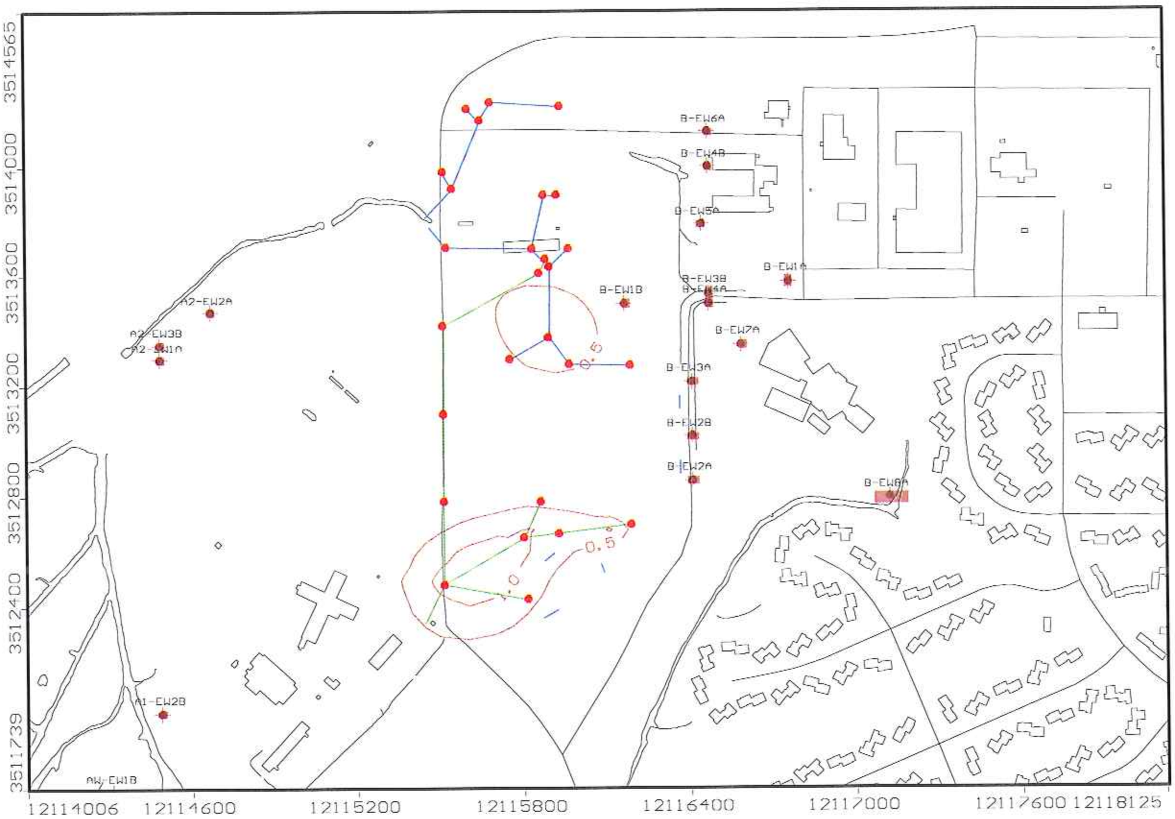
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 28.5 days Modeller: Figure 11 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 12. Drawdown after 31.5 Days (contour interval = 0.5 foot)



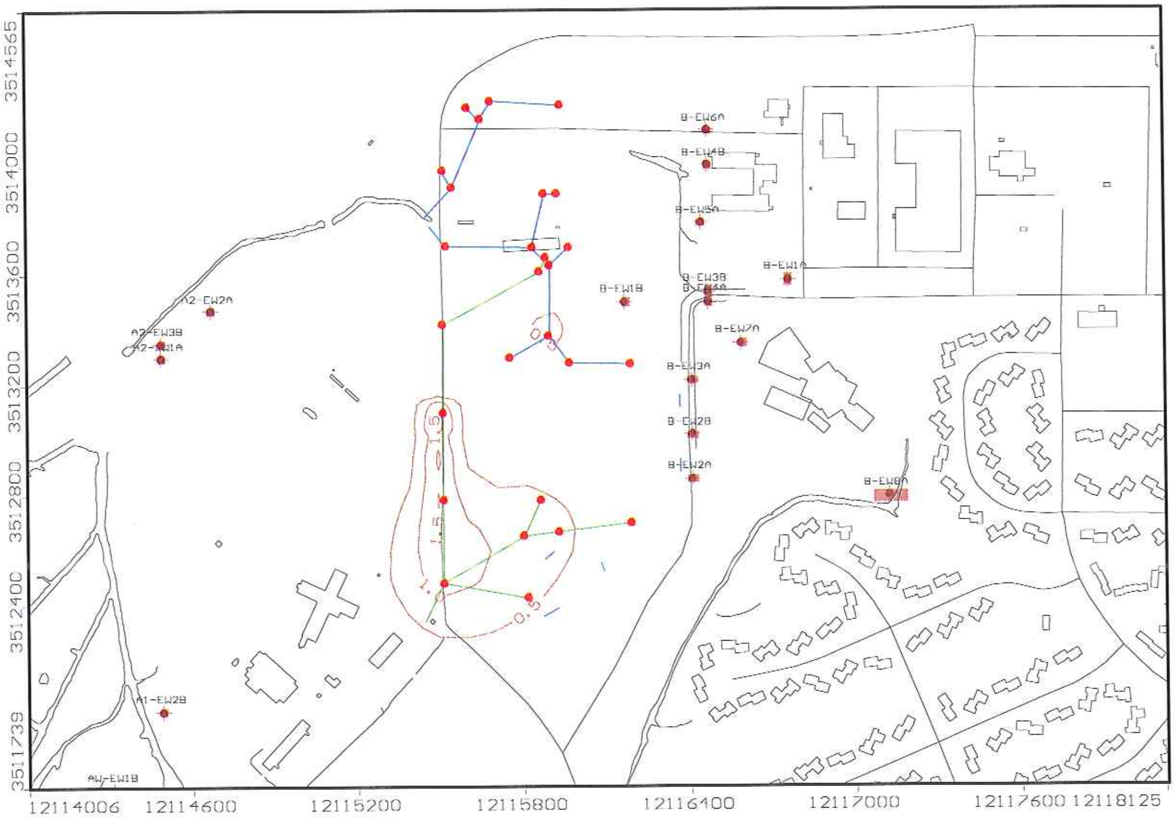
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 31.5 days Modeller: Figure 12 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 13. Drawdown after 39.5 Days
(contour interval = 0.5 foot)



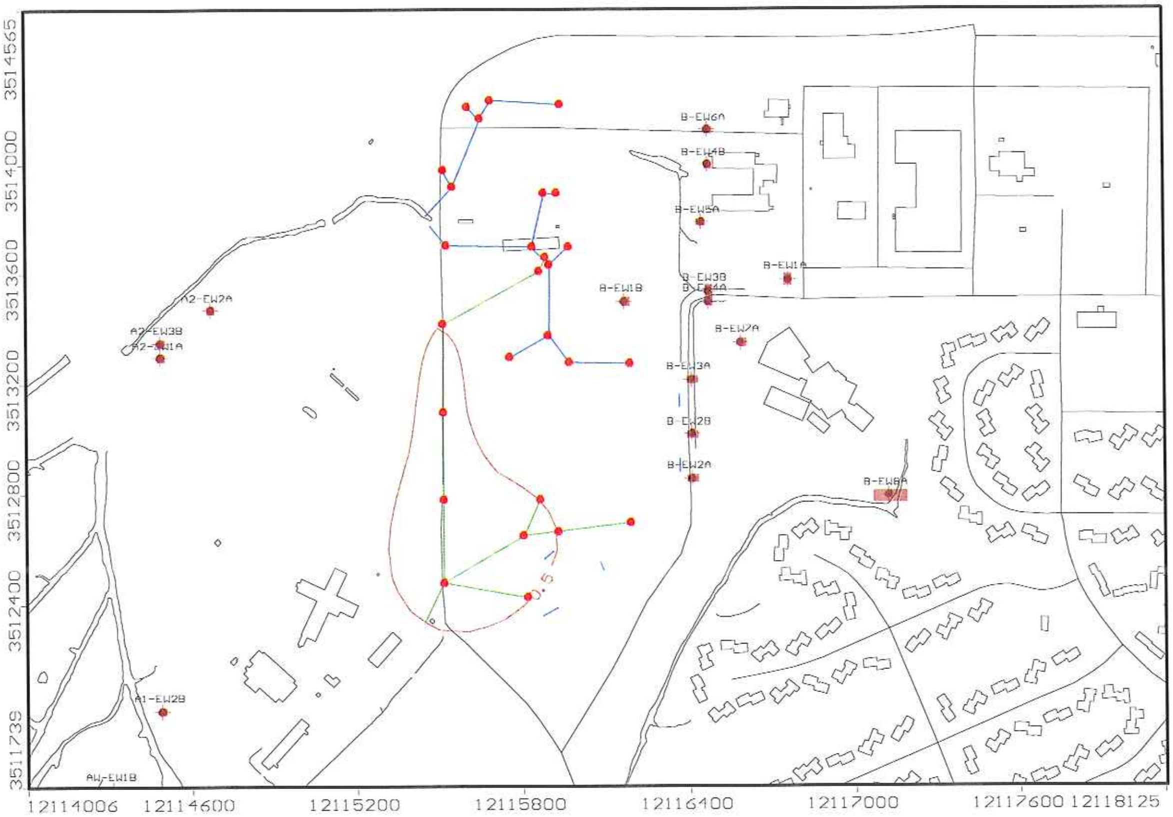
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 39.5 days Modeller: Figure 13 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 14. Drawdown after 45.5 Days (contour interval = 0.5 foot)



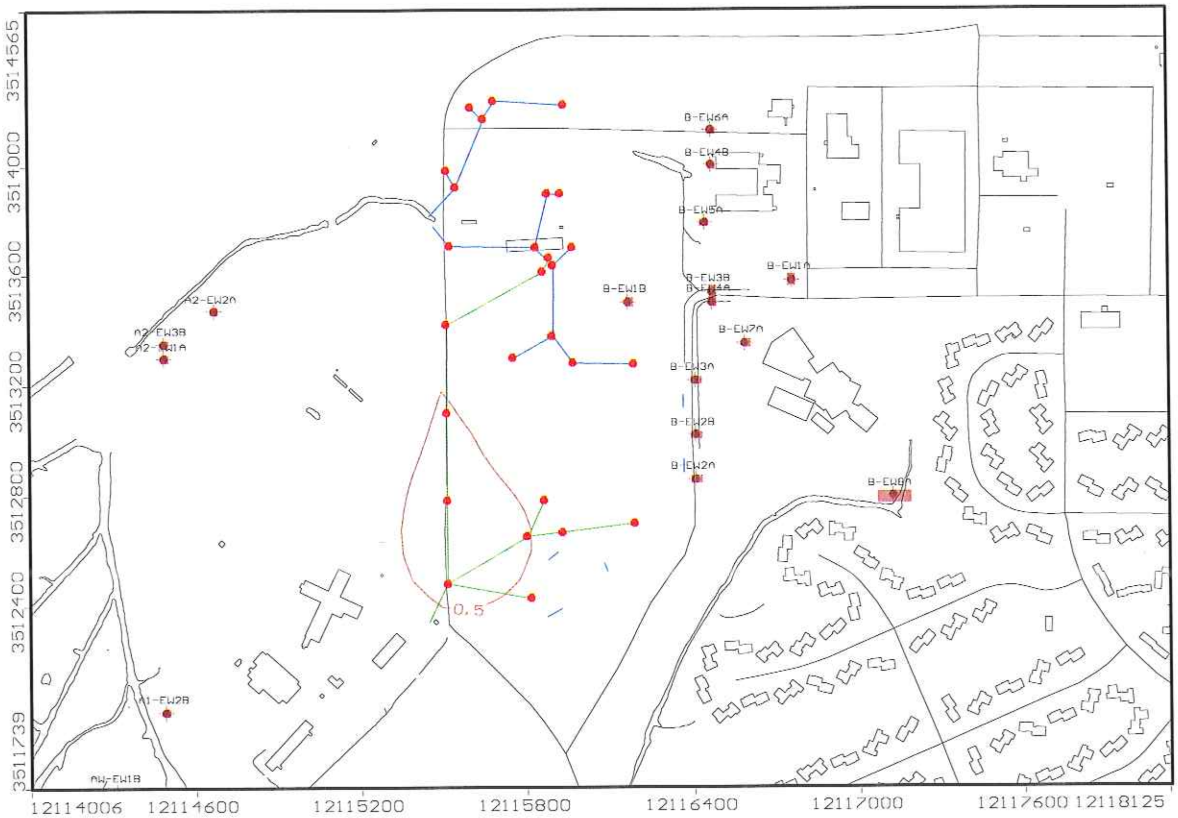
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 45.5 days Modeller: Figure 14 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 15. Drawdown after 50.5 Days
(contour interval = 0.5 foot)



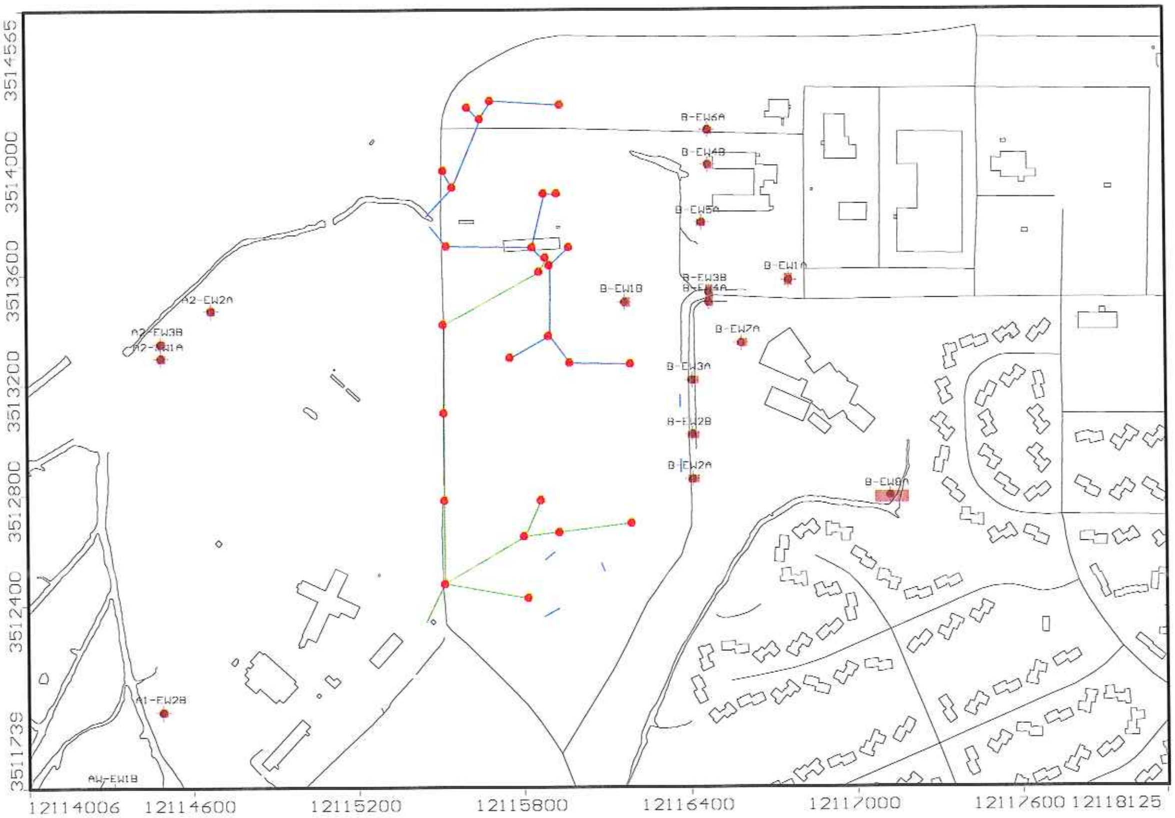
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 50.5 days Modeller: Figure 15 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 16. Drawdown after 60 Days
(contour interval = 0.5 foot)



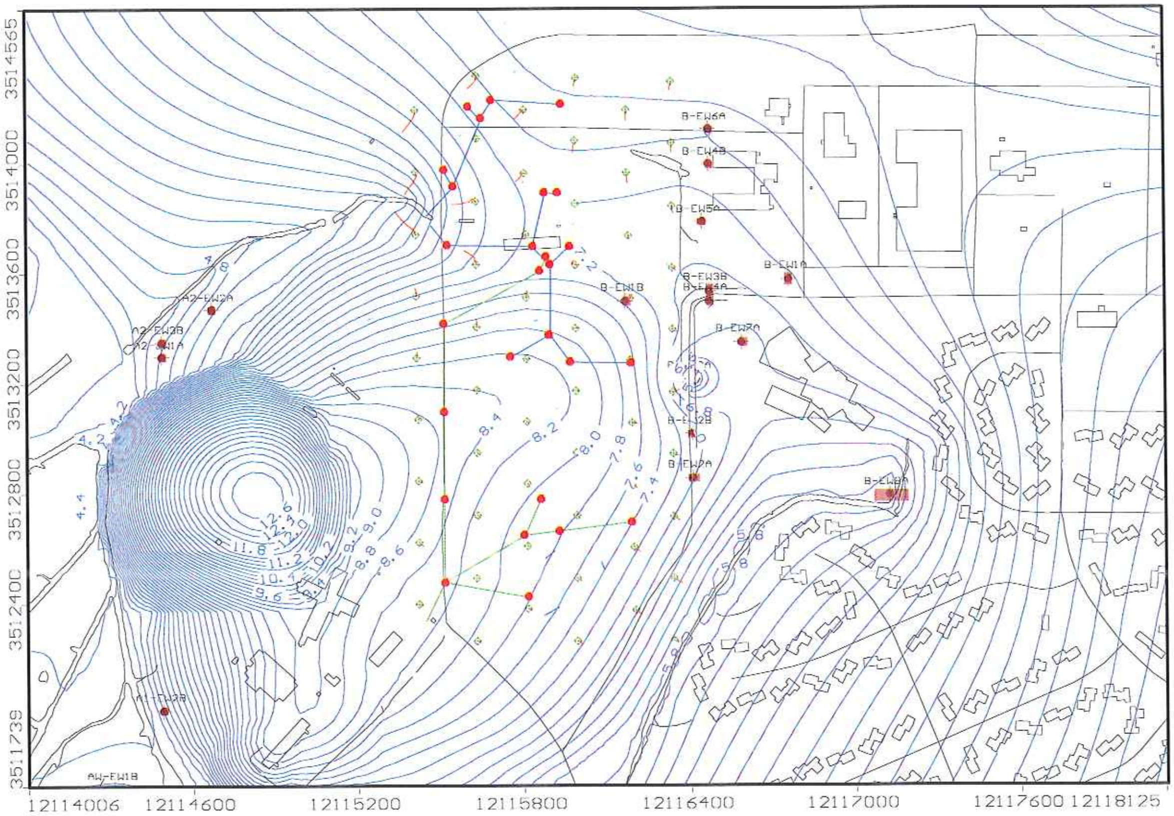
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 60 days Modeller: Figure 16 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 17. Drawdown after 90 Days
(contour interval = 0.5 foot)



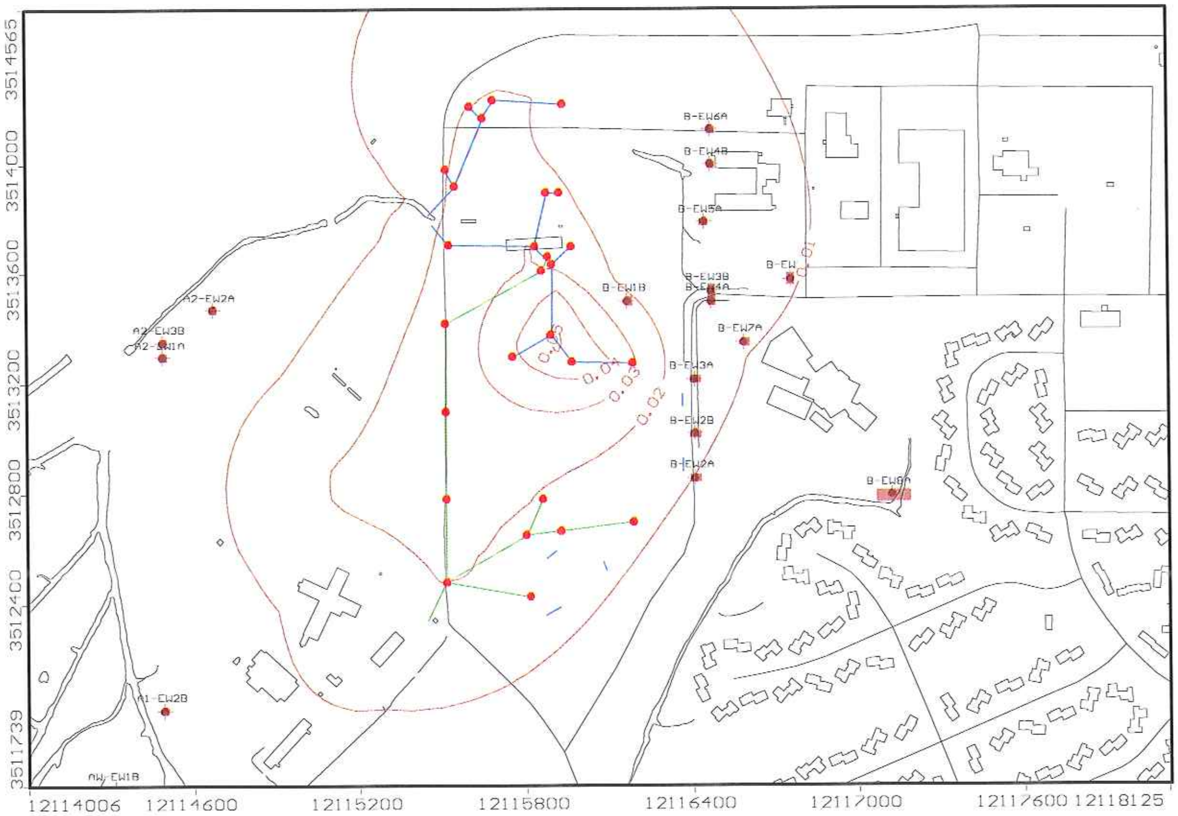
Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 90 days Modeller: Figure 17 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 18. Simulated Hydraulic Heads and Pathlines (90 Days)



Groundwater Management Associates, In Project: Norfolk Naval Base Description: 90-day heads & pathlines Modeller: Figure 20 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995-2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1

Figure 19. Drawdown after 1,000 Days
(contour interval = 0.01 foot)



Groundwater Management Associates, In Project: Norfolk Naval Base Description: drawdown, 1,000 days Modeller: Figure 19 27 May 05	Visual MODFLOW v.3.1.0, (C) 1995–2002 Waterloo Hydrogeologic, Inc. NC: 158 NR: 157 NL: 3 Current Layer: 1